

CLAIMS:

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent is:

1. A liquid crystal display (LCD) device comprising:  
a first substrate having a grooved surface profile;  
an alignment film layer of inorganic or organic material formed on said grooved surface and having said grooved surface profile, said alignment film of inorganic material being aligned in response to an ion beam incident to said grooved surface in a direction parallel to a groove direction;  
a second substrate aligned opposite said first substrate for forming a plurality of LCD cells having liquid crystal (LC ) material deposited therein, wherein LC molecules align parallel to the grooves for enhanced LCD performance.
2. The LCD device according to Claim 1, wherein said material of underlayer comprises one selected from the group comprising:  $\text{SiN}_x$ , hydrogenated amorphous silicon,  $\text{SiC}$ ,  $\text{SiO}_2$ , glass,  $\text{Al}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{SnO}_2$ ,  $\text{ZnTiO}_2$ , and  $\text{InTiO}_2$ ,  $\text{InZnO}_2$ , and other organic or inorganic dielectric film and conducting films.
3. The LCD device according to Claim 1, wherein said alignment film of inorganic material is diamond-like carbon.
4. The LCD device according to Claim 1, wherein a second substrate aligned opposite said first substrate includes a top alignment layer having a flat surface profile.
5. The LCD device according to Claim 1, wherein a second substrate aligned opposite said first substrate includes a top alignment layer having a grooved surface profile.
6. The LCD device according to Claim 1, wherein a surface anchoring energy is increased as compared to LC material deposited between flat substrate surfaces.

7. The LCD device according to Claim 1, wherein aligning the LC molecules parallel to the grooves enables decreased potential energy of said LC molecules.
8. The LCD device according to Claim 1, wherein said alignment film of material comprises one selected from the group comprising:  $\text{SiN}_x$ , hydrogenated amorphous silicon, SiC,  $\text{SiO}_2$ , glass,  $\text{Al}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{SnO}_2$ ,  $\text{ZnTiO}_2$ , and  $\text{InTiO}_2$ ,  $\text{InZnO}_2$ , and other organic or inorganic dielectric film and conducting films.
9. The LCD device according to Claim 1, wherein said grooved surface profile of said alignment film is sinusoidal.
10. The LCD device according to Claim 1, wherein said grooves are not continuous along a lengthwise direction.
11. The LCD device according to Claim 10, wherein the grooves are terminated in a length direction and restart in a slightly different location lengthwise with different height and width of said grooves.
12. A method for forming an LCD device comprising:
  - a. providing a first substrate
  - b. generating grooves on said substrate to form a grooved surface profile;
  - c. depositing an alignment film layer of inorganic material on said grooved surface in conformance with said grooved surface profile,
  - d. aligning said alignment film layer in response to an ion beam incident to said grooved surface in a direction parallel to a groove direction;
  - e) forming a second substrate for alignment opposite said first substrate to form one or more LCD cells having liquid crystal (LC) material deposited therein, wherein LC molecules align parallel to the grooves for enhanced LCD performance.
13. The method for forming an LCD device as claimed in Claim 12, wherein said step b) of generating grooves on said substrate comprises one or more of implementing:

photolithography, ion beam blasting, imprinting, stamping, dipping and pulling the substrate in the liquid glass, oblique deposition, rubbing, and Langmuir Blodgett film coating.

14. The method for forming an LCD device as claimed in Claim 12, wherein said second substrate aligned opposite said first substrate includes a top alignment layer having a flat surface profile.

15. The method for forming an LCD device as claimed in Claim 12, wherein said second substrate aligned opposite said first substrate includes a top alignment layer having a grooved surface profile.

16. The method for forming an LCD device according to Claim 12, wherein said grooved surface profile of said alignment film is sinusoidal.

17. The method for forming an LCD device according to Claim 12, wherein said step b) of generating grooves includes terminating formation of said groove in a lengthwise direction and restarting grooves in a slightly different location lengthwise with different height and width of said grooves.